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Soil
Conservation
Service

Interim Assessment

Physical Impacts of Selected USDA Water Quality Projects

Soil Conservation Service
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University of Vermont

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Abstract

This interim report documents the extent to which 16 USDA water quality projects (8 Hydrologic Unit Areas and 8 Demonstration Projects) are improving and/or protecting water quality by reducing nonpoint-source agricultural pollutants. In their first 3 years, the projects have implemented a wide variety of innovative as well as traditional land treatments and of improvements in management of nitrogen, phosphorus, and pesticides. Although use of physical-process simulation models was not an original requirement for project staffs, the staffs have undertaken to significantly expand their capabilities to select and use such models. Several projects can already document projected reductions in sediment and agrichemical losses from the surface of farm fields or down below crop root zones. Although water quality monitoring was not a project requirement, it was either pre-existing or has been established in 14 projects. Except for 3 or 4 projects, it will be very difficult to use existing monitoring to document water quality improvements attributable to project activities. The primary reasons for this difficulty are insufficient attention during project formulation to the role, design, and execution of an integrated monitoring network, lack of emphasis on annual tracking of improvements in agrichemical use and land management, the dynamics of hydrologic cycles and weather, and short project lives (5 years). Drawing from the knowledge gained by the projects, the report presents preliminary recommendations for future water quality program delivery and implementation.

Executive Summary

The Education, Technical, and Financial Assistance Committee (ET&FA) of the USDA Working Group for Water Quality is implementing 90 Hydrologic Unit Area (HUA) and Demonstration Projects (DP). The projects are designed to improve and/or protect water quality cost-effectively by reducing agricultural nonpoint source pollution. Primary contaminants are nitrate and phosphates from inorganic and organic sources, sediment, and pesticides. The means to achieve reduced pollution are voluntary adoption of a) improved nutrient and pesticide management in crop and livestock enterprises and b) erosion and sediment control practices. This interim report is one of four components of the ET&FA evaluation strategy to document water quality progress. It assesses changes being made in three types of physical impact indicators during the first three years (FY 1990-92) of 16 selected projects, presents issues associated with documenting impacts, and makes preliminary recommendations for future programs. The 16 projects were chosen to represent the major agricultural nonpoint source problems found in the full set of 90 projects.

DP and HUA projects differ from one another. DP staffs address known or potential water quality problems; they demonstrate innovative practices and management changes to area producers who then may adopt these new techniques on their own operations with or without further USDA input. HUA staffs address State-identified water quality problems; they promote producer adoption of more traditional practices, the effects of which on nonpoint source pollution are more generally known.

Indicator Type I: Implementation of Practices and Agrichemical Use

Implementation of improved management practices indicates that producers are taking action to protect water quality. Project staffs brought about implementation of 118 different types of practices. While 62 are sufficiently well established to have SCS national standards, 56 are innovative applications of land, water, and agrichemical management improvements appropriate to local conditions and often developed by State land grant universities. Extension or similar entities. Many of the 56 (e.g., split application of nitrogen; new livestock watering sites; pest scouting) are components of nationally defined practices. Nitrogen pollution reduction practices have been implemented in all 16 projects. Eleven projects applied pesticide management and erosion/sediment control practices.

Implementation figures may understate total change since staff are not charged with tracking practices re-installed by producers in the years following USDA assistance. Producers who, by attending field demonstrations or other educational meetings, have become more aware of water quality pollution and of practices to reduce agricultural sources of that pollution often implement these practices on their operations without further USDA assistance.

The 16 projects achieved sizeable reductions in applied nutrient amounts -- 6.7 million pounds of nitrogen and 4 million pounds of phosphorus. The full significance of these reductions is limited by insufficient data on pre-project applications.

While several projects showed reduction in pesticide use, staff clearly documented that evaluating change in pesticide use is far more complex than nutrient use. The type, rate, and method of application may vary greatly year-to-year due to changes in crop, weather, and pest pressure. Improvements in timing of application can reduce environmental damage even though total application does not fall. Several project staffs promoted change to less toxic pesticides, improved timing and method of application, and targeted assistance to soils with potentially high leaching and runoff problems.

Indicator Type II: Simulated Reductions in Pollutant Loadings

Project staffs significantly raised capabilities to use complex physical-process simulation models that project changes in loss of pollutants from the surface of farm fields or down below crop root zones due to new agricultural methods. The field-scale models used most frequently were EPIC and GLEAMS; AGNPS was the

most used watershed-scale model. Three projects were already able to document a solid link between water quality objectives and simulated edge-of-field loading changes. Six others made significant progress in documenting such linkages. Intensive use of these and other models has provided model developers with a great deal of feedback on how the models are being used and how they can be improved.

Indicator Type III: Monitored Water Quality Changes

Project staffs did a fairly good job in documenting their water quality problems. Fourteen projects have some type of monitoring. In these projects as in previous programs, measuring trends in water quality in a short time (5 years for these projects) is not feasible due to the greater time requirements of the hydrologic cycle. In many projects, monitoring networks were established after the projects were developed. In those cases where monitoring was in place before the projects were planned, it had often been designed for non-project objectives. Except for 3 or 4 projects, it will be very difficult to link practice installation to measured improvements in water quality. Project experiences are rapidly contributing to the knowledge base about the appropriate role of monitoring in water quality programs.

Interim Recommendations for Water Quality Programs

In three years, project staffs have learned a great deal about the complex relationships between land treatment practices and agrichemical management on the one hand and movement of nutrients and pesticides through and across the soil profile towards water bodies. Their on-the-ground experiences are providing the public, USDA program managers, and the research community with opportunities to better understand these relationships. Several recommendations are offered to persons and agencies interested in water quality program development and implementation. They are based on the Assessment team's observation of experiences of these 16 projects as they have implemented concepts, procedures, and program instructions across the Nation.

Those developing and implementing programs to reduce agricultural pollution of water should:

- continue to emphasize the need for project planners to:

  a) establish well-documented, clear, and quantifiable objectives. In terms of **physical impacts**, there are three key categories: improvements in land treatment and agrichemical management, reduction in pollutant losses or potential pollutant loadings to water, and improvement in water quality variables (physical, chemical, and biological), and b) establish procedures to measure levels for each objective before, during, and after the projects.

- provide training in methods (particularly statistics) to track improvements in land treatment and agrichemical management.

- provide training in physical-process simulation models, water quality monitoring (of physical, chemical, and biological variables), and the complementary use of modeling and monitoring within a project.

With respect to models, emphasis should be placed on choosing appropriate field-scale and watershed-scale models, acquiring input data, and interpreting simulation results. Agencies should continue to place high priority on the development of and training in screening tools to identify potential pollutant source areas.

With respect to water quality monitoring, those non-ET&FA agencies with monitoring capabilities must effectively communicate with project staffs with agricultural resource expertise about project objectives. These objectives include the need to be able to document linkage between project activities and water quality improvements. Project planners should be trained in basic concepts of monitoring and evaluation. This may require ET&FA agencies to develop a training curriculum which includes monitoring and modeling for its water quality personnel.

Authorship and Acknowledgements

This report was prepared by John D. Sutton (Soil Conservation Service, Strategic Planning and Policy Analysis Division), Donald W. Meals (University of Vermont), and Ray H. Griggs (Texas A & M University, Blackland Research Center). While it incorporates review comments submitted by many reviewers within and outside of USDA, views expressed are the respoisibility of the authors. The degree of motivation by and involvement of each water quality project staff participating in this Assessment has been high and is gratefully acknowledged.

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I. INTRODUCTION

The United States Department of Agriculture (USDA) Water Quality Initiative is being implemented during FY 1990-94 in response to national concern over declining quality of the Nation's ground and surface water. The Initiative's Water Quality Program Plan requires a program evaluation by the Education, Technical Assistance, and Financial Assistance Committee (ET&FA) of the USDA Working Group on Water Quality[1]. ET&FA developed an evaluation strategy for water quality projects approved for operation under its auspices (see McMullen et al. 1991). This Physical Impact Assessment is a major component of the ET&FA evaluation (see USDA-SCS-SPA, 1992 for more details)[2].

The purpose of the Physical Impact Assessment is to document the extent to which a set of ET&FA projects are making progress in improving and/or protecting water quality by reducing agricultural nonpoint source pollutants. Conditions indicating progress include:

- Implementation of practice/management; changes in use/management of agrichemicals.
- Projected (simulated) reductions in sediment, nutrient, and pesticide loadings.
- Monitored change in water quality variables.

II. PROJECTS SELECTED FOR ASSESSMENT

This report is based on the data and analyses developed by a case study group of eight Demonstration Projects (DPs) and eight Hydrologic Unit Areas (HUAs). Projects selected are:

Demonstration Projects

- Anoka Sand Plain, Minnesota
- Herrings Marsh Run, North Carolina
- Lake Manatee Watershed, Florida
- Mid-Nebraska, Nebraska
- Monocacy River Watershed, Maryland
- Sacramento River Rice Herbicide, California
- Seco Creek, Texas
- Water Quality Demonstration Project-East River, Wisconsin

Hydrologic Unit Areas

- East Sidney Lake, New York
- Illinois River Sands, Illinois
- Inland Bays, Delaware
- Little Bear River, Utah
- Ontario, Oregon
- Sand Mountain/Lake Guntersville, Alabama
- Sycamore Creek, Michigan
- Upper Tippecanoe River, Indiana

Project Characteristics

The 16 projects encompass a large range of geographic settings, agriculture types, and water quality problems characteristic of agricultural nonpoint source water pollution. Table II-1 presents the main characteristics of the projects (Appendix A presents brief project descriptions).

The projects fall into two groups classified by impaired water body, nonpoint source pollutant, and agriculture type:

Group I includes eight projects primarily concerned with surface waters impaired by sediment, nutrients, animal wastes, or bacteria generated by livestock production and/or non-irrigated cropland. DPs in Maryland, North Carolina, and Wisconsin and HUAs in Alabama, Indiana, Michigan, New York, and Utah are in this group. Eutrophication, sedimentation, and oxygen demand have resulted in impairments of water bodies for fisheries, drinking water, recreation, and aesthetics. Common agricultural management deficiencies include lack of erosion control on cropland and streambanks, sediment delivery from cropland, excessive fertilizer application, lack of nutrient crediting for animal waste application, poor animal waste management, and inadequate animal carcass

[1]Three USDA agencies co-chair the Committee. They are the Agricultural Stabilization and Conservation Service (ASCS), the Extension Service (ES), and the Soil Conservation Service (SCS).

[2]Other ET&FA evaluation components are: 1.) Assessment of the Organization and Initial Implementation of the Demonstration Projects Approved in 1990 (Rockwell, Hay, Buck, 1991); 2.) Evaluation of Producer Adoption in the Demonstration Projects (Nowak and O'Keefe, 1992); and 3.) an analysis of cost-effectiveness to be conducted by the Economic Research Service.

Table II-1. Characteristics of Sixteen Physical Impact Assessment Projects

	Demonstration Projects								HUA Projects								
	MD	WI	FL	NC	MN	NE	TX	CA	NY	DE	AL	MI	IN	IL	UT	OR	Total
Surface Water	x	x	x	x			x	x	x	x	x	x	x		x	x	13
River/Stream	x	x		x			x	x				x			x	x	8
Lake/reservoir	x	x	x						x		x		x		x		7
Estuary										x							1
Groundwater	(x)	(x)	x	x	x	x	x			x		(x)	x	x		x	12
Deep	x	(x)				x	x					(x)					5
Shallow	(x)	(x)	x	x	x					x			x	x		x	9
Irrigated cropland		x	x		x	x	x	x					x	x		x	9
Dairy/Beef	x	x	(x)		x				x			x	x		x	x	9
Poultry/Hogs	x				(x)					x	x	x	x				6
Nitrate	x	x	x	x	x	x	x			x	x	x	x	x		x	13
Phosphates	x	x	x	x			x		x		x	x	x		x		10
Sediment	x	x		x			x		x		x	x	x		x	x	10
Pesticides	x	x	(x)	x	x	x	x	x				x	x	x		x	12
Animal Waste	x	x		x	x		x		x	x	x	x	x		x	x	12

Note: (x) signifies a secondary characteristic

disposal practices. The dominant goals are reducing nutrient and sediment loads to receiving waters and/or reducing pollutant concentrations in receiving waters.

The six **Group II** projects focus primarily on contamination of shallow groundwater and associated surface waters with nitrate and pesticides leaching from irrigated cropland. DPs in Florida, Minnesota, and Nebraska and HUAs in Delaware, Illinois, and Oregon are in this group. Nitrate concentrations exceeding EPA's Maximum Contaminant Level in drinking water, excessive nitrogen loading to surface waters in base flow, and detections of corn herbicides and other pesticides in drinking water are typical of the water quality impairments in this group of projects. Common agricultural management deficiencies include excessive nitrogen applications, cultivation on extremely sandy soils, poor irrigation management, and high pesticide application rates. Two of the projects direct their efforts toward threatened, rather than currently impaired, aquifers. The main goals of Group II projects are reducing nitrate and pesticide loads to groundwater and/or reducing pollutant levels in groundwater.

Two DPs do not easily fit into the two groups. The Texas DP focuses on a closely interconnected surface water/groundwater system. The major issues relate to sediment movement from rangeland and nutrient and pesticide movement from cropland, pastureland, and rangeland. The project is concerned with the quality and quantity of water for recharge of the Edwards aquifer as well as the quantity and efficiency of water use.

The California DP is concerned with reducing transmission of herbicide residues used in irrigated rice production to the Sacramento River system. Irrigation tailwater management is the primary agricultural management issue.

Conceptual differences between the DPs and the HUAs are relevant to this Assessment:

- HUAs are located only in areas that States have identified under Section 319 of the Clean Water Act as having significant impairment of water quality by agricultural nonpoint sources. DPs are located in areas that may have impaired water quality or the potential for impairment. They are groupings of adjacent counties or county parts.

  Thus, HUAs tend to focus on remediation of existing problems and their effectiveness might be measured by improvements in water quality. DPs, however, may focus on prevention of problems in a threatened resource.

- HUAs emphasize technical assistance for installation of practices/systems which have been tested by USDA field experience and which have exhibited--in that geographic area--ability to reduce nonpoint source pollution cost-effectively. In contrast, DP staff demonstrate relatively new practices at a limited number of sites.

The 16 projects were chosen to represent the major agricultural nonpoint source problems found in the 90 projects (16 DPs and 74 HUAs) authorized for operation by ET&FA agencies in FYs 1990 and 1991. For example, Table II-2 shows that 75% of the 16 Assessment projects and 74% of ET&FA's 90 projects identified significant groundwater pollution problems; 94% of the 16 and 91% of the 90 projects identified nutrients as a major source of nonpoint source water pollution.

Project Approaches to Assessing Physical Impacts

Approaches to assess impacts include some combination of land treatment implementation records, agrichemical use records, physical process model simulations, and water quality monitoring. Guidance from ET&FA on estimating physical impacts was not provided to project staffs until August 1991. The specific activities undertaken by the projects to evaluate their impact are as varied as the projects themselves. All projects track practice and agricultural management adoption to some degree. Some collect detailed data on changes in actual use of fertilizers and pesticides; others assume producers are following mutually developed management plans.

Project staff are improving their ability to use physical process simulation models to estimate changes in leaching of chemicals below the crop root zone or in surface runoff from the farm field or from the watershed due to application of improved practices.

Table II-2. Representativeness of Physical Impact Assessment Projects

	DPs Assess. (8)	DPs Program (16)	HUAs Assess. (8)	HUAs Program (74)	Total Assess. (16)	Total Program (90)
	%					
Water type						
Surface water	75	75	88	76	81	84
Groundwater	88	94	63	64	75	74
Pollutant type						
Nutrients	88	94	100	91	94	91
Animal waste	50	44	88	42	69	42
Pesticides	100	94	50	72	75	76
Sediment	50	50	75	74	63	70
Minerals & salt	0	0	0	4	0	3

Notes: Assessment projects include the 8 DPs and 8 of the 37 HUAs implemented by ET&FA in FY 1990. ET&FA implemented an additional 8 DPs and 37 HUAs in FY 1991 for Program totals of 16 and 74, respectively.

Fourteen of the projects are engaged in some form of water quality monitoring funded and carried out by a non-ET&FA agency. Monitoring efforts underway include site-level monitoring of particular practices, ambient monitoring of project-area waterbodies, extensive regional monitoring, and intensive monitoring studies specifically designed to evaluate the particular project.

III. PROGRESS IN FY 1990 THROUGH 1992

This section reports improvements in agrichemical use and management, simulated reductions in leaching and runoff of chemicals, measured change in water quality, and key issues related to each.

Improvements in Agrichemical Management

This section discusses practice installation, targeting of practices to problem areas, improvements in agrichemical use, and use of land treatment tracking.

Implementation of practices[3]

There has been substantial practice installation. Some 118 different conservation practices have been installed: 62 are those with Soil Conservation Service (SCS) national standards and specifications;

56 others include State-approved components of nationally defined SCS practices as well as new and innovative practices that are being demonstrated in the DPs to area producers. The most prevalent national practices installed are:

Conservation Cropping Sequence	90,200 acres
Conservation Tillage	76,300 acres
Cover and Green Manure Crop	50,100 acres
Irrigation Pipeline	345,800 feet
Irrigation Water Management	74,500 acres
Drip Irrigation System	8,100 acres
Proper Grazing Use	109,300 acres
Nutrient Management	118,800 acres
Pest Management	42,900 acres
Animal Waste Utilization	30,800 acres

[3]Practices are defined here to include both those conservation practices having national standards defined by SCS as well as new and innovative practices installed for water quality protection or improvement.

Table III-1. Land Treatment and Agrichemical Management Practices Installed vs. Goals, by Project Purpose, for Eight Hydrologic Unit Areas

Purpose/practice [1]	Goals 1990-94	Installed 1990-92	Percent of goal
Nitrogen Management			
Cover & green manure (340)	105,000 ac.	20,962 ac.	20 %
Nutrient management (590)	192,200 ac.	42,591 ac.	22 %
Phosphorus Management			
Conservation tillage (329)	50,000 ac.	14,312 ac.	29 %
Cover & green manure (340)	105,000 ac.	20,962 ac.	20 %
Nutrient management (590)	158,480 ac.	25,566 ac.	16 %
Pest Management			
Conservation tillage (329)	50,000 ac.	14,312 ac.	29 %
Pasture/hayland planting (512)	500 ac.	482 ac.	96 %
Pest management (595)	87,400 ac.	11,760 ac.	14 %
Animal Waste Management			
Waste management system (312)	38	0	0 %
Waste storage standard (313)	64	64	100 %
Waste treatment lagoon (359)	43	20	46 %
Waste storage pond (425)	25	5	20 %
Nutrient management (590)	69,500 ac.	13,111 ac.	19 %
Waste utilization (633)	1,000 ac.	114 ac.	11 %
Erosion/Sedimentation Control			
Conservation cropping (328)	2,100 ac.	97 ac.	5 %
Conservation tillage (329)	57,500 ac.	14,312 ac.	27 %
Critical area planting (342)	10 ac.	4 ac.	40 %
Diversion (362)	5,800 ac.	420 ac.	7 %
Grassed waterway (412)	10,700 ac.	14 ac.	2 %
Pasture/hayland planting (512)	1,200 ac.	482 ac.	40 %
Stripcropping (585/586)	1,500 ac.	70 ac.	5 %
Water/sediment control structure (638)	205	14	7 %

[1] Table includes only practices for which goals were established and which have national standards established by SCS. SCS Practice number is in parentheses.

Installation data for all practices are shown in Appendix B. The data reported above as well as in Appendix B are conservative for two major reasons:

- With some exceptions, staffs record installation of annual practices (e.g. conservation tillage, nutrient management) only in the year when assistance is provided and only those acres where it is provided. On their own volition, producers may implement some of the same practices without any USDA assistance. Reinstallation by producers is tracked only for practices which receive multi-year USDA cost-share including Integrated Crop Management and Integrated Pest Management practices and for long-term agreements.

- Adoption of new practices that do not have nationally set standards by SCS but that are still being tested and installed by producers who have learned of their value through field demonstrations is not tracked.

Practices for protection of water quality from nitrogen pollution have been implemented in all projects. Pest management and erosion and sediment control practices have been applied in 11 of the 16 projects.

Many innovative practices that are highly specific to the local agriculture have been demonstrated. The Florida DP, for example, is promoting more efficient irrigation water management systems developed for vegetable production under plastic mulch on sandy soils. The Oregon HUA places straw mulch and field borders in furrow-irrigated fields to reduce erosion and sedimentation.

Implementation goals for land treatments and agrichemical management were not established in a consistent way for the Assessment projects as a group. Table III-1 compares implementation goals for those practices having national standards and amounts implemented in FY 1990 through 1992 for the eight HUAs. For most practices, full adoption is less than 50 % of stated goals at the mid-point of these 5-year projects.

Practice implementation goals were more relevant to HUAs than to DPs since the objective of DPs is to accelerate voluntary producer adoption of new and innovative practices. It is important to realize that adoption is not simply an adopt-not-adopt phenomenon but has interrelated stages: from awareness and interest, through evaluation and trial on one's own farm, to full adoption of the new technology. The Producer Adoption Study is evaluating this process in the eight DPs (see Appendix C).

An analysis of the apparently slow rate of adoption was not conducted in this Assessment, but two observations can be made. First, 1990 was largely an organizational year for all projects. In no case are these single-agency or even two-agency projects. Project direction, funding, and management involves multiple USDA, other Federal, State, and local agencies. The agencies have various implementation/funding schedules and "institutional inertia". Second, practice implementation generally follows development of the farm/ranch conservation plan and securing funds for implementation of the plan. The extent of this lag was not examined.

Targeting problem areas

For land treatment to achieve water quality goals cost-effectively, practice installation should be targeted to the most critical problem areas within a project. Assessment team interviews and on-site observation indicate that staffs generally have a strong appreciation for the need to target. However, targeting is not a simplistic concept in voluntary programs. Project staffs can and do, however, target demonstration and education efforts in problem areas. Targeting is also made more difficult when there are multiple factors to target such as highly leachable soils for pesticides or for nutrients, endangered species, and water for drinking.

Different degrees of targeting have occurred. One method, at times very informal and qualitative, is reliance on local staff knowledge concerning location of problem areas. Staffs that have gone a bit further in specifying problem areas have, for example, systematically identified and targeted observed gullies and streambank erosion or livestock operations where animal waste runs off directly to adjacent streams.

Targeting appears to have been approached and documented most systematically in about one-half of the projects and on soils with potential leaching or surface runoff problems for pesticides. See Table III-2. The key seems to have been availability and use of a first-order screening technique called the Soil-Pesticide Interaction Screening Procedure (SPISP). Documented use of systematic targeting of nitrogen management (organic and inorganic) and/or phosphorus management, and erosion and sediment control - all highly significant practices for water quality - was not as evident in the selected projects. As noted earlier, team observation suggested that targeting for nutrients and sediment did occur.[4]

In several projects, staffs consider all soils in their area to be problem soils. While such a generality may be broadly true, it does not support spending limited funds for greatest impact.

Reported improvements in agrichemical use

Reported reductions in nitrogen and phosphorus use are summarized in Table III-3. Reductions in nitrogen applications ranged from 13 pounds/acre to 358 lbs/ac. Reductions of phosphorus ranged from 0.5 lbs/ac to 297 lbs/ac. Total reductions over FY 1990-92 were a reported 6.7 million pounds of nitrogen and 4 million pounds of phosphorus.

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[4]The Farm *A* Farmstead Assessment System (Farm*A*Syst) is a USDA program by which producers use a series of questionnaires and fact sheets to assess potential point sources of groundwater pollutants at the farmstead. The practice was used by several projects (see practice O272 in Appendix 2).

Table III-2. Implementation of Measures to Control Pests

	Soil Leaching Potential for Pesticides			
Practice	Severe	Moderate	Slight	%
Pest Management[1]	48%	34%	18%	100%
Brush Management	5%	3%	92%	100%
Prescribed Burning	2%	1%	97%	100%
Pest Scouting	72%	12%	16%	100%
Pesticide Selection	86%	10%	4%	100%
Pesticide Application/Timing	70%	30%	0%	100%
Mechanical Control of Pests	90%	10%	0%	100%
Crop Rotations	57%	7%	36%	100%
Integrated Pest Management Plan	89%	2%	9%	100%

[1]SCS Practice No. 595. Other practices listed may be components of this national practice.

Table III-3. Reported Changes in Nutrient Use

		Nitrogen		Phosphorus	
Project	Purpose[1]	lbs/ac	total	lbs/ac	total
HUA #1	n,p	-358	-1,296,300	-297	-1,075,400
HUA #2	n,p	0	0	0	0
HUA #3	n,p	-10	-40,224	-0.5	-1,844
HUA #4	p	----	----	----	----
HUA #5	p	0	0	0	0
HUA #6	n,p	-62	-824,000	-78	-969,000
HUA #7	n	-143	-1,018,274	-47	-334,523
HUA #8	n	-48	-679,000	----	----
DP #1	n,p	-46	-871,000	-43	-818,000
DP #2	n,p	0	0	----	----
DP #3	n,p	-13	-16,935	-11	-17,353
DP #4	n	-25	----	0	0
DP #5	n	-30	-344,907	----	----
DP #6	n	-62	-765,966	----	----
DP #7	n,p	-17	-163,644	-19	-140,925
DP #8	----	----	----	----	----

Source: Projects' 1992 annual report tables V-D.1 & V-D.2. Only includes reductions on monitored demonstration sites in the DPs.

[1] Nutrients to be controlled as project objective: n = Nitrogen and p = Phosphorus
---- Data not available

The significance of these reductions is limited by inadequate knowledge of pre-project (baseline) quantities applied.

Nutrient budget worksheets and other nutrient and/or pesticide planning documents developed by project staffs were widely used to estimate actual changes in chemical applications. About one-third of the projects collected producer data on actual changes in agrichemical use. Many project reports noted that improvements in nutrient applications do not always mean appreciable reductions in rate or quantity.

Several reports noted that evaluation of changes in pesticide use is far more complex than for nutrient use. The type, rate, and method of pesticide application may vary from year to year in response to changes in crop, weather, pest pressure, and other factors. Producers may change pesticide formulations or choose pesticides with lower leaching and/or runoff potential. Neither improvement would necessarily be reflected in total pounds of active ingredient applied.

Integrated Pest Management (IPM), a practice used in several projects, strives to optimize pesticide use. Improvements in timing through pest scouting may reduce environmental impact even though total quantity of active ingredient does not change.

Documenting agrichemical management through land treatment tracking

Detailed tracking of land treatment implementation can help document improvements in agrichemical management. The projects display a wide variety of quality and intensity of tracking efforts. However, there are some common themes:

- Knowledge of baseline conditions is critical to assessing change. One-half of the projects had such information.

- Ten projects have procedures in place to record improvement in management including, where appropriate, nutrient and pesticide application methods and rates.

- When producers receive cost-share for Integrated Crop Management (ICM) and IPM, they must annually certify to project staff that they are applying nutrients and pesticides at agreed-upon rates.

- When ET&FA agencies sign a Long Term Agreement (LTA) with the producer, staff annually have the producer certify that practices are being installed and maintained as detailed in the plan.

- Data confidentiality is an important and at times highly sensitive issue for producers. In several projects, producers and/or agribusiness are very reluctant to provide information on agrichemical applications.

Simulated Projections of Pollutant Loading Reductions

The physical process simulation models being used in the Assessment projects are of two types:

- Field scale models. These models generally represent a homogeneous land unit like one field with the same soil, weather, crop rotations, topography, management, and chemical inputs. Such models help analyze "on-site" problems, i.e., nutrient and pesticide leaching below the bottom of the crop's root zone and surface runoff past the edge of the farm field. They do not directly address changes in the quality of the receiving waters. They do address potential change in pollutant loadings to water bodies.

- Watershed (or basin) scale models. These models are used to help analyze off-site problems such as the location of nutrient sources and the quantity and timing of pollutant loadings.

One project (the Florida DP) uses a model that addresses groundwater loadings and flow. However, to the Assessment team's knowledge, there are no others models generally available that explicitly simulate linkage between agricultural management and groundwater quality.

Results from field-scale models

Project staffs have progressed significantly in developing capabilities to use field-scale simulation models to project potential change in pollutant loadings. Eight staffs are capable of using at least one model efficiently with minimal additional assistance; six need significant additional assistance.

Table III-4. Simulation Model Usage by Project

Model	HUA Project State								Demo Project State							
	AL	DE	IL	IN	MI	NY	OR	UT	CA	FL	MD	MN	NE	NC	TX	WI
AGMAN						p										
BARNY						U										U
CMLS							U			U				p		p
CREAMS											U			p		
DRAINMOD										p						
EPIC		p	U	U	U	p	U	U		U	U		U	U	U	U
GLEAMS	U	p	p				U			p		U				
NLEAP		p	p	p		p	p			p		U	p			
PSIAC								p								
SPUR															p	
AGNPS	U	p		U	U			p								U
GWLF						U										
SWRRBWQ				p		p	p									p
VS2DT										U						

U - currently using
p - plan to use

Table III-4 shows that EPIC is used by 11 projects. Other models used are GLEAMS (three), BARNY (two), CREAMS and CMLS (one project each).[5]

Three projects presented simulated edge-of-field loading changes in their 1992 annual reports for selected practices (see Table III-5). The percentage reductions were derived by comparing long-term (at least 30 years) annual average simulations, with BMPs installed, with simulations under pre-treatment (baseline) conditions. These percentage reductions refer to the number of individual fields where producers installed practices; they do not represent reductions in potential loadings for the entire project area. Six additional projects have significant efforts underway to resolve data and model documentation problems that should allow them to simulate loading changes for their next annual report. Generally, project staffs have not yet included simulation results in their annual reports. It is important that staffs report both reductions in example, one reported example showed that nitrogen losses from the root zone would increase by over 100% for a given practice. Such an increase could be an important response to an agricultural practice since, for example, reduction in nitrogen losses to runoff water could subsequently amplify losses out of the root zone.

Eight projects used a first-level screening tool to help target land treatments to vulnerable areas. The most commonly used was SPISP or its automated version. NPURG. Both help develop information on which soil-pesticide combinations have the greatest potential for pesticide leaching or runoff.

[5]Model acronyms are spelled out in Acronyms following Appendix C.

Table III-5. Simulated Percentage Reductions in Contaminant Loadings [1]

Nitrogen	
Percolating below the bottom of the root zone	64-73 %
Leaving the edge of the field in runoff	63-66 %
Phosphorus	
Leaving the edge of the field with eroded sediment	63-73 %
Pesticide	
Percolating below the bottom of the root zone	90 %
Eroded sediment	
Leaving the edge of the field	91 %

[1] as reported in FY 1992 Annual Reports of three projects for a limited number of farm fields.

Table III-6. Organizational Level of Models Operation

--------------SCS--------------			----------CES----------		---Other---
Project Office	State Office	NTC[1]	Project Office	University	State and Federal
FL	AL	AL	UT	FL	AL
OR	DE	MN		IN	TX
TX	IL			MD	
AL	IN			MN	
	MD			NE	
	MI			NY	
	MN			NC	
				WI	

[1]National Technical Center of SCS.

Within the projects the models are being run by various organizations and at different levels within the respective organizations (see Table III-6). Although not obvious from the table, it may be significant to mention that in those projects whose annual reports cited simulated changes between pollutant loadings and agricultural practices, university staffs were closely involved in model use.

Some issues in use of field-scale models

Generally, models were not run by field staffs. This is understandable given a) the expertise and responsibility of field staffs to plan and assist with implementing conservation practices directly with producers; b) the complexities of learning which of several models may be most appropriate and what data to obtain, how to obtain data cost-effectively given limited staff time, how to run the model and interpret the large quantities of output; and, c) the short time (about 18 months) to begin use of these highly sophisticated tools. However, moving model operation away from field staffs has potential hazards of which those responsible for model operation need to be particularly aware. Interpretation and use of output simulations without careful thought may show improbable results, a consequence that can quickly--and at times unjustifiably--damage model credibility and preclude further use of a potentially valuable analytical tool.

Because of the simplifications and assumptions that these tools must incorporate to simulate highly complex real-world physical processes, it is

important that readers of annual reports understand the significance of model projections. Readers would benefit if annual reports cited, along with modeled numerical results,

- the model used and number of years in the projection;
- both the previous and new agricultural system being simulated;
- the representativeness of the soils and systems modeled;
- confidence/accuracy/probability discussion;
- changes in leaching/runoff of other pollutants that may have accompanied the reductions in the pollutants of most concern; and
- significant model strengths or limitations.

The projects' intensive use of the models has been particularly valuable in that use has revealed that there are agricultural practices and/or issues: a) that the models do not address; b) that cannot be addressed usefully unless the model has been validated and verified to local conditions; and c) that can only be addressed with difficulty because model documentation is not clear.

The following practices and/or issues are among those deemed not well addressed by CREAMS, EPIC, GLEAMS, and/or NLEAP. Not every item applies to every model: animal grazing; nutrient and pesticide banding; buffer strips/riparian zones/grassed waterways; interactions between pesticides; flood-irrigated rice; furrow irrigation; gully erosion; high water tables; maximum contaminant level warnings; minor but high value crops (e.g. vegetables and citrus); mixed plant populations; nitrogen inhibitors; pesticide emulsifiers, stickers, and wetting agents; pest population dynamics; rangeland; stochastic input/output (variability); subsurface drainage; subsurface flow (base flow); trickle irrigation; pesticide and nutrient volatilization; wetlands.

Watershed-scale models

At this early stage in project operations, one project was able to document linkage between project objectives and simulated basin scale effects on water quality (using AGNPS) and three more projects are on the right track. A total of six projects have developed advanced capabilities in AGNPS, and two more have developed very basic capabilities.

Watershed-scale models such as AGNPS and SWRRBWQ are subject to the same types of limitations noted for field-scale models. Project staffs indicated several additional issues: need to convert AGNPS to a continuous system (more than one storm event); linkage of model outputs to a geographic information system (GIS); an output notice when Maximum Daily Contaminant Levels are exceeded; more sub-basins in SWRRBWQ and the ability to transform and degrade pesticides, nitrogen, phosphorus in water bodies.

Water Quality Monitoring

ET&FA policy recognizes the importance of water quality monitoring to establish trends and changes due to its projects. Given the expertise of ASCS, ES, and SCS in land and agrichemical management and expertise of other Federal, State, and regional agencies to monitor water quality, ET&FA has encouraged its project staffs to work with these other agencies to plan, fund, and conduct water quality monitoring. Project staffs in turn would concentrate on management improvements to reduce agricultural pollutant loadings to water bodies.

Status of monitoring and evaluation programs

Fourteen projects have monitoring programs. They include monitoring that relies partially on state programs that may be:

- ambient programs existing before project approval, designed for objectives of the monitoring agencies, and which happen to include some stations in the project area (e.g. California and Florida DPs, Delaware and Utah HUAs);
- short-term intensive programs focused on some specific area or problem which overlaps the project area (e.g. Maryland and Wisconsin DPs);
- specialized programs designed for the project (Michigan HUA).

Not surprisingly, the programs exhibit a great deal of variety. Some key examples of work being undertaken by Federal or regional agencies include:

- USGS is monitoring streamflow and stream chemistry in the Texas DP and has conducted studies of groundwater chemistry in the Delaware HUA.

- USDA-ARS is operating five automated surface water quality monitoring stations in the North Carolina DP.

- Tennessee Valley Authority and Auburn University are helping monitor a constructed wetland system in the Alabama HUA.

- The Minnesota Pollution Control Agency, Management Systems Evaluation Area (MSEA) program, Minnesota Agricultural Experiment Station, ARS, and USGS are conducting site monitoring in the Minnesota DP.

Some examples of monitoring being conducted by researchers through the land grant universities and State Agricultural Experiment Stations include:

- Studies of fertilizer and pesticide movement in groundwater under vegetable fields and citrus groves in the Florida DP.

- Biomonitoring and rangeland plot studies in the Texas DP.

Regional or local agencies also contribute to monitoring. The Kosciusko County Health Department, for example, is conducting a monitoring program specifically in support of the Indiana HUA. In the Nebraska DP, several Natural Resource Districts are monitoring nitrate movement in the vadose zone on fields in the project area.

Interim results

There are few water quality monitoring results to be reported at this time. Projects with significant monitoring activities have correctly stated that it is too early to expect significant changes in water quality or improvements in use impairments. One project (the California DP) presented definitive monitoring results concerning response to treatment. They show that, at demonstration sites, improved irrigation water management systems reduce pesticide discharge by 60 to 96% compared with conventional systems.

Water quality data discussion

Water quality data are important to guide project management, target implementation, and evaluate progress. Eight of the FY 1992 annual reports contained water quality data but discussion about the data was often quite weak.

Several projects provided particularly useful discussions:

- The North Carolina DP report discussed observed water quality with respect to values for key chemical and biological variables in subwatersheds within the project area. Staff documented impairments from agricultural runoff and made potentially useful inferences in targeting land treatment efforts.

- A thorough nonpoint source load allocation study that was reported in the Michigan HUA report quantified pollutant loads and will serve as a baseline for later paired watershed analysis.

- Extensive baseline biomonitoring data were presented and discussed in the Texas DP report.

- The Delaware HUA report included discussion of available water quality data on surface and groundwater quality conditions even though the available monitoring activities will probably not be capable of documenting changes in water quality. Presentation and consideration of the available data are still useful, however, as documentation of baseline water quality for long term considerations.

- The California DP presented pesticide residue data from the three tailwater irrigation systems being demonstrated, together with economic data to support recommendations on which system should or would likely be adopted by growers in the project area.

Ability of monitoring networks to detect change

Although the existence of appropriate monitoring was not a criterion for project selection, the ability of existing monitoring networks to contribute to project impact assessment is a key issue for this report. With few exceptions, it will be difficult for the monitoring networks operating in the 16 projects to

detect changes in water quality due to land treatments. The purpose of this section is to use examples taken from selected projects to highlight those monitoring network features that are useful and important in creating the ability to document such detection.

Monitoring networks Monitoring networks that have been developed specifically in support of project water quality and land treatment objectives are apt to detect changes in water quality and tie those changes to the project's land treatment program. Examples include:

- the California DP where in-stream pesticide levels above and below the three demonstration irrigation systems are monitored to evaluate the ability of systems to reduce tailwater pesticide concentrations;

- the Michigan HUA where a paired watershed study is underway;

- project-specific monitoring efforts that are underway in the Alabama, Indiana, and Utah HUAs and in the Florida and North Carolina DPs.

Monitoring design A monitoring design that can effectively detect change must:

- evaluate parameters and/or impairments expected to change following treatment;

- be located near the impaired use and/or the treatment area;

- be collected at enough locations and with sufficient frequency to capture the inherent variability of the system; and

- be capable of controlling for the inevitable variability in climate, season, and hydrology that tends to obscure the effects of treatment.

Again the California DP and the Michigan HUA provide two useful examples. In California, the combination of above/below demonstration site monitoring of tightly controlled irrigation systems with an established long-term trend monitoring network in the Sacramento River should be capable of detecting changes resulting from the DP. In the Michigan HUA, the use of a nearby control (untreated) watershed will help account for hydrologic variability.

Several projects (e.g., the Florida, Texas, Minnesota, and Nebraska DPs and the Oregon HUA) monitor primarily individual practices, fields, or plots. They should provide excellent evidence of individual practice effectiveness. At the same time, the projects will be challenged to extrapolate site level results over the project area.

Tracking land treatment and changes in chemical rates, timing, and methods Monitoring change in land management is critical to achieve accurate information on relationships between treatment and water quality response. In only a few projects were mechanisms designed and implemented to record annually actual quantities of nutrients and pesticides applied, application methods used, and dates of application. Such record-keeping is critical to advancing the state of knowledge (in both program and research communities) about the water quality response of major types of ground and surface water bodies to improved agricultural management.

Nature of the hydrologic system Monitoring network design must take into account the area's hydrologic system. Long lag times between land treatment and groundwater movement can prevent the detection of change in the project time frame. This is a difficulty faced in the Delaware and Oregon HUAs, for example, and in projects where large quantities of pollutants have accumulated in the soils and sediments. The Wisconsin DP and the New York HUA are examples where detecting water quality response due to reduced chemical losses will be confounded by such accumulations.

Monitoring in an impaired water body such as a reservoir, for example, is not likely to show a response when there are other major unmonitored sources of pollutants, when the project area contributes only a small or undocumented proportion of the total water or pollutant load, or when the extent of treatment is limited. The Alabama and New York HUAs and the Florida DP must grapple with this issue.

IV. Interim Recommendations

These recommendations stem from the Assessment team's observation of the experiences of eight water quality Demonstration Projects and eight HUAs during the first three years of their five-year lives. They reflect lessons being learned by project staffs (at the field and state office levels) as they implement concepts and program instructions for reduction of nonpoint source pollutants from agriculture. They are offered to agencies and persons interested in water quality program development and implementation.

Those developing and implementing programs to reduce agricultural pollution of water should continue to emphasize the need for project planners to establish well-documented, clear, and quantifiable objectives and likewise to establish unbiased procedures to measure pre-project (that is, either baseline level or trend) and post-project levels for each objective, as well as changes during project implementation. Secondly, they should provide technical guidance and training in preferred, cost-effective methods to track improvements in land treatment and agrichemical management. And thirdly, they should develop technical guidance and training in the use of physical-process simulation models, in water quality monitoring (on physical, chemical, and biological variables), and in how these technologies should be used to complement one another.

Acceptable objectives for water quality projects, in terms of physical impacts, should fall into one of three categories:

- improvements in land treatment and agrichemical management;
- reduction in pollutant losses from crop or livestock enterprises (this could also be stated as reduction in potential pollutant loadings to water);
- improvement in specific water quality variables (physical, chemical, biological).

Simulated and/or monitored values for variables in these first two categories (e.g., tons of animal waste managed properly, acres put under split application of nitrogen, nitrate leaching past the bottom of the crop root zone; pesticide attached to eroded sediment, etc.) are critical measures of direct progress toward land treatment and agrichemical management improvement objectives. But they should be considered only as **indirect** measures of **water quality** protection or improvement since clear cause-and-effect links between practice installation and receiving water quality are rarely made (either in these selected projects or in previous public programs). Only monitored values for variables in the third category (e.g., nitrate concentration in water, dissolved oxygen levels, type/number of benthic macroinvertebrates, total suspended sediment, etc.) should be considered **direct** measures of progress toward **water quality** protection or improvement objectives. A successful water quality project is one that is making cost-effective progress toward its clearly stated objectives.

For tracking improvements in land treatment and agrichemical management, serious consideration should be given to development and use of unbiased statistical methods that would allow:

- estimating actual agrichemical application rates and acreages under improved management and taking account of units of practices installed;
- ascertaining whether producers who have received assistance to install annual practices, such as nutrient management, continue to implement those practices as designed in subsequent years;
- determining the degree of independent adoption by producers of practices demonstrated by project staff.

With respect to models, emphasis should be given to developing capabilities to choose appropriate simulation models, both field-scale and watershed-scale, acquire reliable input data at least cost, and use the selected model properly including output interpretation and sensitivity analysis. Proper use means using models in the project planning process to help identify critical pollutant source areas, the nature of the pollution problem, design of water quality monitoring, and potential (and relative) effects of alternative management systems on pollutant loadings.

Closely related to simulation models are screening tools. Assessment project staffs successfully targeted pest management practices because they had a first-

level screening tool, SPISP, to identify potential problem soils. Agencies should continue to place a high priority on the development of and training in the use of screening tools for nitrogen, phosphorus, and sediment to assist in identifying potential pollutant source areas and areas to target management improvements. Linkage to total maximum daily load (TMDL) tools could be useful.

While the ET&FA agencies will probably continue to rely heavily on other Federal, State, and regional agencies for primary technical expertise in design, installation, operation, and interpretation of water quality monitoring systems, the level of participation by project staffs in such activities should be increased. Water quality monitoring and evaluation must be an integral part of project planning, design, operation reporting, and evaluation. Development and operation of water quality monitoring to assess project effectiveness must be a partnership between ET&FA and other agencies. Project staffs, with their agricultural resource expertise, must communicate effectively with monitoring operators about project objectives, and agricultural and agricultural management/land use issues. Water quality data should be used, to the extent possible, to help target land treatment and assess interim progress. Project staffs should participate in water quality monitoring activities and in data management and interpretation to the fullest extent possible.

To achieve such cooperation, project planners and staffs should be trained in basic concepts of monitoring and evaluation. This may require ET&FA to develop a training curriculum which includes monitoring for its water quality staffs.

Appendix A

Descriptions of Assessment Water Quality Projects

Anoka Sand Plain Demonstration Project
Minnesota

This project is located in a region characterized by sandy soils that are low in organic matter and that overlie a shallow aquifer. Some 330,000 acres of crops are grown under both irrigated and non-irrigated conditions. Dairy and poultry are the main livestock production activities.

Some 70,000 acres are irrigated. Most producers apply nitrogen at planting or as a sidedress during the summer. Few use a nitrification inhibitor. Over four-fifths use herbicides, and most use crop rotations for weed control. Nearly three-fourths of the irrigators either do not practice scheduling or use the "hand-feel" method. Animal waste management is an integral component of all nutrient management plans where producers apply animal waste to cropland fields. ICM is being demonstrated on 40 farms.

Nitrate concentrations exceeding 10 milligrams/liter have been documented in 30% of wells tested, with the highest levels in areas of intense irrigated crop production. There is also an incidence of triazine herbicide detections in area groundwater. Because the Anoka aquifer is believed to recharge the Mississippi River and another aquifer to the south, water quality problems in the project area may be a threat to the drinking water supply for Minneapolis-St. Paul.

East Sidney Lake Watershed HUA
New York

East Sidney Lake is a reservoir created in 1950 for flood control and subsequently opened for recreation. Significant groundwater resources occur only in the floodplain soils of Ouleout Creek. East Sidney Lake has been highly eutrophic since its inception. Lake water quality is impaired for swimming and stressed from an aesthetic standpoint as a result of sediment, nutrients, and oxygen-demanding substances from the watershed. Oxygen depletion in the deeper lake waters is common. In some areas, private wells have been contaminated with nitrate and bacteria.

There are 138 agricultural operations in the 70,800-acre watershed. Corn and hay are the principal crops grown, primarily in support of the 52 dairy operations. Tillage is predominantly conventional. Nutrient application methods are generally those designed to maximize crop production for livestock operations. Because storage facilities are limited animal waste is normally spread daily except in the winter, when it is stacked on the ground. The primary agricultural pollution causes are: barnyard runoff, overgrazing, poor manure management, improper manure storage, and livestock in streams. Principal pollutants are phosphorus and microorganisms such as *Giardia lamblia.*

Herrings Marsh Run Demonstration Project
North Carolina

This 5,100-acre project is in southeastern North Carolina. Soils are medium to coarse in texture and are subject to seasonally high water tables. Surface waters have been designated as "support threatened" because of biological oxygen demand (BOD), nutrient, and sediment inputs from agricultural nonpoint sources. Groundwater quality is also threatened by nitrogen and pesticides.

This project is marked by intensive agricultural activity, including major poultry and swine operations. In terms of acreage, major crops are corn, soybeans, vegetables, tobacco, and cotton. Tillage is largely conventional. Nutrient and pesticide application rates and methods are based on tradition. Nutrients, particularly nitrogen, are the primary nonpoint source pollutants. Animal manure provides more than half of the nitrogen needed for crop production, yet 90% of crop nutrients are purchased in the form of mineral fertilizers. Dead poultry disposal is also a major concern. More than 50 different pesticides were in use at the time of project inception. Animal waste lagoons are typically not built to current SCS standards and may not be properly managed. Many are undersized and subject to overflow.

Illinois River Sands HUA
Illinois

The 250,000-acre project area is level to moderately sloping with well drained sandy soils underlain by an extensive sand and gravel aquifer that lies 3 to 12 feet below the surface. This shallow aquifer is the main rural drinking water source. Some 450 farms produce corn, soybeans, and vegetables. Center pivot irrigation is extensive. A few specialty crops require pesticide application every 3-4 days through

the growing season. Although impairment of the groundwater has not yet been documented, detection of high concentrations of nitrate and trace levels of pesticides in shallow groundwater in a 1986-87 survey sounded a warning of significant threats to drinking water quality.

Inland Bays HUA
Delaware

This 157,000-acre HUA includes three basins in southeast Delaware: Rehoboth Bay, Indian River Bay, and Little Assawoman Bay. Topography is very gently sloping. Dominant soils are sandy and well drained to excessively well drained. Most streamflow derives from baseflow; less than 10% of annual precipitation flows into the Bays as surface runoff. Over 75% of nutrient loads entering the Bays are believed to be transported in baseflow.

Agriculture is dominated by livestock production, particularly poultry, but also hog, beef, and dairy operations. Cropland, mainly corn and soybeans, occupies about 40% of the HUA. Two-thirds of corn acreage receives nearly 300 lbs/ac of nitrogen. Atrazine, metolachlor, and alachlor are the primary pesticides used. The rapid growth of the poultry industry has created problems for storage and utilization of poultry manure and for dead bird disposal.

Agriculture supplies 35-55% of the annual nitrogen load to the bays. Use of nitrogen fertilizers and spreading of poultry manure in excess of crop needs on sandy soils are the major sources of nitrate loading to groundwater. Another source is concentrated animal housing. All three bays have excessive levels of nitrogen during most of the year. Low dissolved oxygen levels, high bacteria counts, and high nitrate levels all contribute to impairment of fish populations, shellfishing, and recreation. Nitrate contamination of groundwater is serious; one-third of all wells tested had nitrate exceeding drinking water limits.

Lake Manatee Demonstration Project
Florida

Lake Manatee provides drinking water for Bradenton and nearby communities on Florida's central Gulf Coast. The lake is highly eutrophic with algae blooms being common. Because the upper reaches of the lake's 88,000 hectare watershed lie in a phosphate mining region, phosphorus levels in lake water are very high (>200 μg/l) and the lake is considered to be primarily nitrogen limited. High levels of nitrate have been documented in shallow groundwater and drainage waters from traditionally-managed citrus and vegetables. These elevated nitrate levels are thought to result from excessive application of nitrogen fertilizers (300 - 400 lbs/ac on vegetables is typical) and poor irrigation water management. Nitrates and pesticides are transported in shallow baseflow to the lake.

Little Bear River HUA
Utah

Agriculture within this 197,000-acre project is devoted primarily to livestock feed production, grazing, and wildlife. Predominant land uses are rangeland (70%), irrigated cropland (20%), and dry cropland (5%). Major crops are small grains and alfalfa. Tillage systems are conventional. Very few waste storage facilities exist; manure is spread all year long except during the winter when it is stacked on the ground. Application rates vary from 2 to 20 tons/acre. Little manure is incorporated into the soil when crop planting begins.

The Little Bear River watershed is a major source of pollutants to Hyrum and Cutler Reservoirs and to the Bear River. Pollutants, their sources and methods of transport include: sediment from streambank and channel erosion; nutrients and coliform bacteria from pasture, cropland, and feedlots; irrigation return flows; and phosphorus from rangeland during spring snowmelt runoff. Currently, known water quality problems are mainly related to surface water.

The Little Bear River has shown violations of Utah water quality standards since 1984/1985 for phosphorus, nitrogen, BOD, dissolved oxygen (DO), and bacteria. Poor water quality due to eutrophication has impaired fisheries and recreational values in Hyrum and Cutler Reservoirs.

Mid-Nebraska Water Quality Demonstration Project, Nebraska

Soils in this irrigated corn region of south-central Nebraska uplands are generally medium to fine textured loess soils that overlie groundwater 100-300 feet deep. Typical nitrogen application on corn is 180 lbs/ac. Three-fourths of all irrigation on the 33 demonstration farms is by furrow, the remainder by center pivots. About half of the cooperators apply

nitrogen in the fall, regularly use crop consultants, and use banded herbicides.

Based on well testing, groundwater has shown trends of increasing nitrate and atrazine levels. High nitrate levels correspond to irrigated corn areas. While impairment of the deep aquifer has not been observed, continued deep percolation of excess irrigation water is expected to drive nitrates and possibly pesticides in the vadose zone downward into the aquifer.

Monocacy River Watershed Demonstration Project, Maryland

Over 65% of this central Maryland watershed is in agricultural use, primarily cropland. There are some 3,500 farms in the watershed; livestock operations dominate, including dairy, poultry, and hogs. Surface waters are impaired for aesthetics, recreation, fisheries, and commercial uses by nonpoint sources. Principal pollutants are sediment and nutrients from a combination of inorganic fertilizers and animal wastes. Groundwater in shallow limestone aquifers is threatened by pesticides and nitrates from agricultural chemicals and fertilizers.

**Ontario HUA
Oregon**

Intensive irrigated agriculture is practiced in the semi-arid valleys of eastern Oregon. Major crops, in terms of acres cultivated, are wheat, sugar beets, onions, potatoes, dry beans, field corn, sweet corn, and mint. Ninety percent of the cropland is furrow irrigated; 200-400 lbs/ac of nitrogen are common. Dacthal (used only on onions) is the pesticide of main concern. It is banded at 4 lbs/ac or broadcast at 6-9 lbs/ac.

Drinking water is impaired by high concentrations of nitrate nitrogen, with levels exceeding 10 mg/l EPA (drinking water standard) in 30% of wells tested. Sodium, arsenic, selenium, and lead (all of which occur naturally in the watershed) have been detected at concentrations exceeding EPA's Maximum Contaminant Levels in groundwater. Dacthal has been detected in some groundwater samples, but well below critical health levels. Irrigation and widespread fertilizer and pesticide use are believed to be the major contributors to groundwater quality problems. High levels of sediment and nutrients in surface waters result from furrow irrigation.

**Rice Pesticide Demonstration Project
California**

Rice agriculture is the only economically viable crop on the poorly drained clay soils of this Sacramento Valley project. The predominant irrigation method is continuous flooding from sowing to harvest. Water flows from one field to another, and excess water enters a drain at the end of the field, where it may be recycled, reused in a downstream field, or discharged to the river.

The water quality problem is pesticide residue released to surface waters during rice irrigation. The pesticides of concern are Molinate and Bensulfuron. Conventional systems which release used irrigation water directly into surface waters allow pesticide residues into agricultural drains and waterways, killing fish and impairing drinking water supplies.

Pesticide levels in public waters have been reduced over 90% since 1983. The primary means of reducing residual pesticide levels in rice irrigation has included holding of irrigation tailwater on the rice field or on set-aside lands to allow natural degradation to occur. Future State water quality standards mandate ever-decreasing pesticide concentrations, and the decreasing availability of idle acreage for water holding serves as an incentive for producers to adopt the improved irrigation tailwater practices demonstrated in the project.

**Sand Mountain-Lake Guntersville HUA
Alabama**

This 400,000-acre HUA in northeast Alabama includes the Lake Guntersville Reservoir, the major source of water-based recreation in the area. Agriculture is composed of small livestock operations, primarily poultry and hogs; one-third of the project area is in corn, soybeans, and potatoes. Poultry operators spread 6-15 tons of litter annually (usually in one spring application) for average application rates of 345 lbs/ac for nitrogen and 470 lbs/ac for phosphorus. Most (90 percent) swine lagoons overflow during the wet season. Spreading lagoon waste is not common as it is relatively labor intensive for the amount of nutrients applied. Some 75 percent of the HUA's cropland erodes above "acceptable levels"; two-thirds of the cropland is tilled under systems that leave more than 15% residue. Many uses of Lake Guntersville, including public water supply, recreation, fisheries, and

aesthetics are impaired by sediment, nutrients, and bacteria.

Groundwater contamination may also be a problem. Bacterial contamination has been recorded in a high percentage of area wells and much of the HUA has a high potential for nitrate leaching.

Seco Creek Demonstration Project
Texas

This predominantly rangeland watershed of 170,000 acres overlies the Edwards Aquifer, the sole source of water supply for San Antonio. In the recharge area, land use is predominantly rangeland (150,000 acres). Beyond the recharge area is 16,000 acres of cropland of which 2,600 acres is irrigated. In many cases, streams enter the aquifer through open caves in the karst recharge zone, providing no filtration for surface waters. In the upper reaches of the watershed, runoff flows into Seco Creek, which flows until it reaches the recharge area and then enters the aquifer. Below this recharge zone, however, there is no flowing stream except during occasional extreme high flow events when the creek flows once more to recharge downstream reservoirs. Because surface waters can move directly into the Edwards Aquifer, the potential for polluting this aquifer with agricultural runoff and sediment is considered sizable. Groundwater is currently suitable for most purposes.

Sycamore Creek Watershed HUA
Michigan

This project includes some 68,000 acres of primarily agricultural land in south-central Michigan. Agriculture is predominantly livestock based, including dairy, hogs, and beef. Sources of nonpoint source pollutants include severe erosion and over-application of fertilizers and pesticides. Corn, soybeans, and wheat are the principal crops cultivated. Tillage is primarily conventional. Water quality is significantly affected by sedimentation and oxygen depletion, which impair the suitability of the stream for recreation and for fish habitat. Violations of Michigan water quality standards for dissolved oxygen have been recorded. High nutrient concentrations contribute to eutrophication and threaten groundwater quality.

Upper Tippecanoe River Watershed HUA
Indiana

This 209,000-acre project in northeastern Indiana is underlain by outwash deposits of sand and gravel, which form the principal aquifer along the Tippecanoe River. High well yields, high permeability, and shallow water tables are characteristic of the area. There are 217 natural lakes and impoundments in the area. About 75% of the watershed is devoted to agriculture, dominated by swine and poultry. The main crops are corn, soybeans, wheat, and hay. Tillage is 80 percent conventional. Fertilizer is normally broadcast in fall or spring before planting. Nearly all animal waste is broadcast spread. Because most facilities have a 90-day or less storage capacity, manure is spread 2-3 times annually, often on the same fields. Rates of 10-20 tons/acre are common.

One-third of the watershed is a major erosion problem area. Sediment and associated nutrients are significant contributors to lakes eutrophication. Pesticide leaching and runoff potentials are high for one-half and one-fourth, respectively, of the HUA's soils. Sampling of private wells from 1984 through 1987 showed that 40% to 55% of the wells contained nitrate levels exceeding 10 mg/l.

Watershed Demonstration Project - East River
Wisconsin

Nutrients, pesticides, and toxics from agriculture are contributing to groundwater and surface water contamination in this 141,000-acre watershed. Nearly a quarter of the watershed lies in metropolitan Green Bay. Agriculture is dominated by 400 dairy operations with some 42,000 animal units. Major crop rotations are typically 2 years of corn, followed by small grains, and 2-4 years of hay. Tillage is 82 percent conventional. Most farmers have only a minimal manure management program, apply excessive amounts of nitrogen and phosphorus, and do not scout for pests. A typical phosphorus application rate is 120 lbs/ac, of which 30 percent is from inorganic fertilizer and 70 percent from manure. A typical nitrogen application rate is 220 lbs/ac, of which 25 percent is from inorganic fertilizer, 40 percent from manure, and the remainder from legumes such as alfalfa. Pesticide application methods and rates are extremely variable from producer to producer. Major reaches of the East River flow over fractured limestone (karst) and rapidly recharge shallow aquifers used by the rural

population. Some 30% of watershed soils have high groundwater pollution potential. High nitrate, pesticide, petroleum, and VOC levels have been documented in shallow private wells, and there is some evidence suggesting leakage to deeper regional aquifers. Surface water problems are important. Problems with excessive sediment, phosphorus, and toxics from agriculture have caused high turbidities, algal blooms, and fish consumption advisories. Since the project was initiated, priorities have shifted away from groundwater quality to phosphorus and sediment loading to the surface waters of nearby Green Bay.

Appendix B: USDA-Assisted Practice Installation On Sixteen Assessment Projects

Practices/Activities[1]		Units	HUAs	Demo Sites	Non-Demo Sites[2]	Total
312	Waste Management System	number	96	1	1	98
313	Waste Storage Structure	number	65	3		68
314	Brush Management	acres	0	4,166		4,166
322	Channel Vegetation	acres	4	0		4
324	Chisel/Subsoiling	acres	0	818		818
327	Conservation Cover	acres	5,943	0		5,943
328	Conservation Cropping Sequence	acres	71,161	19,013		90,174
329	Conservation Tillage	acres	69,829	6,512		76,341
330	Contour Farming	acres	291	622		913
338	Prescribed Burning	acres	0	64		64
340	Cover/Green Manure Crop	acres	23,312	2,761	24,000	50,082
342	Critical Area Planting	acres	4	17		21
344	Crop Residue Use	acres	10,119	2,761	4,911	7,746
350	Sediment Basin	number	1	0		1
352	Deferred Grazing	acres	0	55,706		55,706
359	Waste Treatment Lagoon	number	24	12		5
362	Diversion	feet	1,165	1,875		3,040
382	Fencing	feet	3,220	91,700		94,920
388	Irrigation Field Ditch	feet	0	37,358		37,358
393	Filter Strip	acres	8,103	68		8,171
410	Grade Stabilization Structure	number	92	0		92
411	Grass/Legume Rotation	acres	297	0		297
412	Grassed Waterway	acres	39	28		67
425	Waste Storage Pond	number	14	3		17
428	Irrigation Ditch Lining	feet	14,678	0		14,678
430	Irrigation Pipeline	feet	27,351	35,041	283,360	345,752
430FF	Irrigation Steel Pipeline	feet	365	0		365
441a	Drip Irrigation System	acres	0	450	7,600	8,050
442a	Sprinkler Irrigation System	acres	4,024	0		4,024
442b	Sprinkler Irrigation System	number	449	0		449
443a	Surface/Subsurface Irrigation	acres	0	1,414	5,282	6,696

[1]Practice codes from ADSWQ User's Guide, Version 1.1, 1992. Practices whose codes do not start with "I" or "O" are SCS-certified practices in its National Handbook of Conservation Practices. Generally, ADSWQ "I" practices/activities have quantifiable water quality effects. ADSWQ "O" practices are other practices/activities that are important to meeting water quality goals, while they may not have quantifiable effects.

[2]Only five of eight DPs reporting.

Practices/Activities		Units	HUAs	Demo Sites	Non-Demo Sites	Total
443b	Surface/Subsurface Irrigation	number	0	15	72	87
447	Tailwater Recovery	number	5	30	185	220
449	Irrigation Water Management	acres	16,094	11,482	46,906	74,482
464	Irrigation Land Leveling	acres	622	0		682
472	Livestock Exclusion	acres	50	283		333
484	Mulching	acres	1,158	0		1,158
500	Obstruction removal	acres	87	0		87
510	Pasture/Hayland Management	acres	7,771	5,625		13,396
512	Pasture/Hayland Planting	acres	1,547	385		1,932
516	Pipeline	feet	357	0		357
521	Pond Sealing	number	1	0		1
528	Proper Grazing Use	acres	2,000	107,287		109,287
548	Grazing Land Mechanical Treatment	acres	0	80		80
550	Range Seeding	acres	74	0	0	74
556	Planned Grazing System	acres	0	55,190	0	55,190
574	Spring Development	number	1	31	0	32
584	Stream Channel Stabilization	feet	2,000	0	0	2,000
585	Stripcrop-Contour	acres	69	928	0	997
586	Stripcrop-Field	acres	54	0	0	54
587	Water Control Structure	number	4	426	0	430
590	Nutrient Management	acres	57,612	53,738	7,492	118,842
595	Pest Management	acres	11,409	22,752	8,692	42,853
600	Terrace	feet	7,900	0	0	7,900
606	Subsurface Drain	feet	5,888	0	0	5,888
612	Tree Planting	acres	5	0	0	5
614	Trough or Tank	number	1	0	0	1
633	Waste Utilization	acres	20,222	10,596	0	30,818
638	Water/Sediment Conservation Basin	number	14	6	0	20
642	Well	number	367	9	0	376
645	Wildlife Habitat Management	acres	0	96,574	0	96,574
I205	Composted Waste Disposal	acres	0	208	0	208
I210	Knifing Animal Waste	acres	0	89	0	89
I211	Plow Down Animal Waste	acres	0	502	0	502
I214	Waste Application Time/Rate	acres	0	576	0	576
I215	Soil Testing	acres	5,458	9,554	0	15,012
I216	Fertilizer Application Timing	acres	1,414	4,066	0	5,480
I217	Tissue Analysis	acres	0	2,786	0	2,786
I220	Reduced Yield Goal	acres	0	685	0	685
I221	Nutrient Credit-Crops	acres	80	1,411	0	1,491

Practices/Activities		Units	HUAs	Demo Sites	Non-Demo Sites	Total
I222	Split Application Nitrogen	acres	1,355	4,355	0	5,710
I223	Banding Nutrients	acres	1,450	1,706	0	3,156
I224	Nitrogen Inhibitors	acres	0	539	0	539
I226	Alternate N Formulation	acres	0	509	0	509
I227	Double Cropping	acres	0	532	0	532
I228	Rainwater Storage	acres	0	116	0	116
I234	Scouting	acres	76	5,903	0	5,979
I235	Pesticide Selection	acres	76	4,495	0	4,571
I236	Pesticide Application/Timing	acres	0	1,674	0	1,674
I240	Rice Water Holding Period	acres	0	305	0	305
I244	Mechanical Control of Pests	acres	0	2,749	0	2,749
I247	Crop Rotation/Pest Control	acres	76	1,761	0	1,837
I248	Water Table Monitoring Floats	acres	0	369	0	369
I249	Fully Enclosed Seepage System	acres	0	306	2,500	2,806
I251	Irrigation Timing/Duration	acres	0	4,292	0	4,292
I252a	Irrigation Rates	acres	0	100	0	100
I253a	Microjet System Improvement	acres	0	11	0	11
I257	Surge Irrigation	acres	95	100	0	195
I258	Bubbler	number	16	0	0	16
I259	Furrow Diking	acres	0	910	0	910
I260	Low Energy Precision Application	acres	0	240	0	240
I261	Irrigation Scheduling	acres	1,619	4,718	0	6,337
I262	Sprinkler Irrigation	acres	819	0	0	819
I297	Stream Livestock Exclusion	animals	60	20	0	80
I298	Buffer Strip	acres	0	40	0	40
O162a	Irrigation Efficiency Cropland	acres	0	2,662	0	2,662
O162b	Irrigation Efficiency Cropland	ac-in	0	10	0	10
O213	Manure Spreader Calibration	number	78	21	0	99
O219	N Quick Test	number	11	98	0	199
O229a	Nutrient Management Plan	acres	0	2,528	0	2,528
O230	Irrigation Water N Test	number	0	63	0	63
O231	Root Zone N Sample	number	0	547	0	547
O232	Nitrate Sample-groundwater	number	0	340	0	340
O233	Manure Analysis	number	209	66	0	275
O238a	IPM Plan	acres	0	1,258	0	1,258
O239	Pesticide Storage	number	0	1	0	1
O243	Pheromone Traps	number	0	2	0	2
O255	Irrigation System Effect	number	0	240	0	240
O256	Flow Meters	number	0	42	0	42

Practices/Activities		Units	HUAs	Demo Sites	Non-Demo Sites	Total
0264	Well Testing	number	0	34	0	34
0272-82	Farm*A*SYST	number	6	0	48	54
0283	Install Weather Station	number	0	2	0	2
0290	Soil Moisture Monitoring	number	0	117	0	117
0901	Cropland Treated	acres	0	17,382	0	17,382
0902	Pasture/Hayland Treatment	acres	0	2,594	0	2,594
0903	Rangeland Treated	acres	0	28,884	0	29,884
0904	Animal Waste Stored	tons	0	70,540	0	70,540

Appendix C

Producer Adoption Study - Abstract

The objectives of this study are to (1) measure adoption across time by specified target audiences, (2) account for practice demonstrations and other communication influences on this decision process, and (3) interpret the findings in such a way that future technology transfer efforts will be enhanced.

The study is based on a quasi-experimental research design using both demonstration and comparison areas. Comparison areas for seven of the eight DPs were identified by local staff. Large representative samples of producers in each DP and comparison area are being surveyed at four times during 1992-1995. Participating landusers were selected using spatial sampling techniques.

Analyses will focus upon determining the extent to which program efforts contribute to the accelerated adoption of water quality BMPs beyond that which would have occurred in the absence of any similar program. The rates at which the target audiences move through the adoption process reflects the effectiveness of the communication program and provides an indication of the social and economic acceptability of particular practices. A second objective is to measure the *relative effectiveness of on-farm demonstrations* as a mechanism for communicating the salient attributes of selected BMPs to producers.

Producer adoption of BMPs is seen as a process rather than as an adopt-not adopt concept. The adoption model is a set of interrelated stages, from:

- awareness and interest, through
- evaluation and trial, and finally to
- full adoption and/or adaption of a technology

The study team selected a subset of practices being promoted by each DP for adoption process measurement. Baseline estimates for each practice are in Nowak-O'Keefe (see References).

REFERENCES

McMullen, J.R. (ASCS), A.J. Weber (ES), and P.M. Tidd (SCS). 1991. Transmittal memorandum for "Annual Reporting of Hydrologic Unit Area and Demonstration Project Accomplishments and Impacts: Interim Guidelines." July 23, Washington, D.C.

Nowak, P.J. and G.J. O'Keefe. 1992. "Baseline Report: Evaluation of Producer Involvement in the USDA 1990 Water Quality Demonstration Projects." Submitted to USDA under Cooperative Agreement between USDA Ext. Serv. and Univ. of Wis. Madison, WI.

Rockwell, S.K., D.R. Hay, and J.S. Buck. 1991. Organization and Implementation Assessment of the FY90-94 Water Quality Demonstration Projects. Submitted to USDA under Cooperative Agreement between USDA Ext. Ser. and Soil Cons. Serv. and the Univ. of Nebraska, Lincoln NE.

USDA-SCS, Goss, D. 1988. "Soil Pesticide Interaction Ratings, Field Office Technical Guide, Section II". Bulletin No. 430-9-3.

USDA-SCS-SPA. 1992. "Assessing Physical Impacts of Water Quality Projects." Strategic Planning and Policy Analysis Division, Washington, D.C.

USDA-SCS-SPA and Texas A & M Univ. 1992. "Automated Data System for Water Quality: User's Guide." Version 1.1. Washington, DC.

ACRONYMS

Agencies and Programs:

ARS - USDA Agricultural Research Service

ASCS - USDA Agricultural Stabilization and Conservation Service

CES - the Cooperative Extension System

EPA - U.S. Environmental Protection Agency

ES - USDA Extension Service

ET&FA - Education, Technical, and Financial Assistance Committee of the USDA Working Group on Water Quality

SCS - USDA Soil Conservation Service

USGS - U.S. Geological Survey

Other Acronyms:

ADSWQ - Automated Data System Water Quality

AGMAN - Agricultural Manure Management Program Model

AGNPS - Agricultural NonPoint Source Model

BARNY - Barnyard Area Runoff Nutrient Yield Model

CMLS - Chemical Movement in Layered Soil Model

CREAMS - Chemicals, Runoff, and Erosion from Agricultural Management Systems Model

DP - ET&FA Demonstration Project

DRAINMOD - A Water Management Model for Shallow Water Table Soils

EPIC - Erosion-Productivity Impact Calculator Model

GLEAMS - Groundwater Loading Effects of Agricultural Management Systems Model

GWLF - Generalized Watershed Loading Functions Model

HUA - ET&FA Hydrologic Unit Area

LEACHM - Leaching Estimation And CHemistry Model

NLEAP - Nitrogen Leaching and Economic Analysis Package Model

NPURG - National Pesticide/Soils Database and User Decision Support System for Risk Assessment of Ground and Surface Water Contamination Model

PSIAC - Pacific Southwest Inter-Agency Committee

SPISP - Soil-Pesticide Interaction Screening Procedure

SPUR - Simulation of Production and Utilization of Rangelands Model

SWRRBWQ - Simulator for Water Resources in Rural River Basins-Water Quality Model

VS2DT - U. S. Geological Survey program for solving problems of solute transport in variably saturated porous media.